Natural Resource & Environmental Economics Working Group
Department of Agricultural Economics
T e x a s A &M U n i v e r s i t y
College Station, TX 77843-2124

September 19, 2007

Ms. Nancy Beller-Simms
NOAA, Office of Global Programs
1100 Wayne Ave.
Suite 1210
Silver Spring, MD 20910-5603

Dear Nancy,

The final report for NOAA's Human Dimensions of Global Change Research (HDGCR) Program Grant Number NA030AR4310055 "Development of Climate Forecasts Decision Making Teaching Materials for Junior High School Teachers and Students" is enclosed. The following components make up the final report.

1) An Executive Summary which provides an overview of the study, along with major findings.

2) Two refereed journal articles that appeared in Science Scope, a journal directed towards middle / junior high school science teachers, sent via mail.

    Mjelde, J.W., K.K. Litzenberg, J.E. Holye, S.R. Holochwost, and S. Funkhouser. AFires, Floods, and Hurricanes: Is ENSO to Blame?@ *Science Scope* 30(March 2007): 38-42.

    Holye, J.E., J.W. Mjelde, and K.K. Litzenberg. AWeather to Make a Decision.@ *Science Scope* 29(February 2006): 24-27.

3) A working paper from the project directed towards the education academic community.

    Mjelde, J.W., and K.K. Litzenberg. "Using Science Curriculum to Teach Decision Making: A Probabilistic Approach." Working Paper. Department of Agricultural Economics, Texas A&M University, College Station, TX. 2007.

4) Binders that contain the teaching material for the Weather and Climate Units, sent via mail..

5) Project Web Site – TeachingDecisionMaking.tamu.edu.

If you need further clarification, please feel free to contact me at (979) 845-1492 or e-mail j-mjelde@tamu.edu.

Sincerely,

James W. Mjelde
Professor

Development of Climate Forecasts Decision Making Teaching Materials for Junior High School Teachers and Students

NOAA's Human Dimensions of Global Change Research (HDGCR)
Program Grant Number NA030AR4310055

Executive Summary

James Mjelde
Dept. Ag. Econ.
Texas A&M University
College Station, TX 77843-2124
j-mjelde@tamu.edu
(979) 845-1492

Kerry Litzenberg
Dept. Ag. Econ
Texas A&M University
College Station, TX 77843-2124
litz@tamu.edu
(979) 845-7624

Project Summary: This project was an interdisciplinary approach to developing teaching materials for junior high school science teachers by integrating concepts from decision theory, math, reading, geography, and statistics into the climate science curricula. University faculty from the College of Education and economists from the Department of Agricultural Economics at Texas A&M University partnered with science and mathematics teachers from Texas junior high schools to form the development team. The team developed two learning units, WEATHER and CLIMATE. These units provide materials for junior high school teachers to use to teach integrated decision making while at the same time meeting national and Texas teaching standards for science education. The self-contained learning units include modules that introduce students to probabilistic thinking, provide instruction in decision making approaches, and discuss weather or science concepts in an integrated fashion. While the context for these decisions was science based, the actual decisions were decisions that are relevant to the lives of students in this age cohort. Both units were tested in Texas junior high school classrooms and students demonstrated statistically significant improvement in decision making capabilities using a pre-test / post-test scenario when compared to the control group. Statistically, the learning units were gender and ethically neutral.

Approach: University faculty first met with selected junior high school teachers and students to provide the basis for the science units. It was decided to create two learning units: one oriented toward the weather science (typically taught in the Texas grade six classrooms); and the second dealing with climate science units (typically taught in eighth grade classrooms). Decision making situations that were relevant to junior high students' lives were integrated into the learning units to present the probabilistic-based decision making material. The relevance of these situations was important to the context of the learning modules. Focus groups of students were used to extract situations that were common to the daily lives of the junior high students to use throughout the learning modules. For the main instruction, the two situations used planning a school fund-raising function, either outside or inside depending on weather forecasts and participating in an outdoor or indoor soccer league depending on climate forecasts. Special care was used in the development of the learning materials to be sure that they were not gender or ethnically biased. Additionally, information was included in all learning modules to enable teachers to accommodate both slower and accelerated learners. Once the learning material was developed, the material was presented in the classroom to test the effectiveness of the units. University faculty were not present in the junior high school classrooms during the administration of the teaching modules to be sure the teachers could use the material without assistance. Data were collected from the students (parent and student releases were obtained) to enable the statistical analysis of student performance. Students were given a pre-test to establish their prior knowledge of the science material and their probabilistic decision making capabilities. Then, differing amounts of the material were taught to different classes. A control class was included that was not taught the decision making material, but only the science material. Finally, a post-test was administered. Statistical evaluation of the pre- and post-tests was conducted to determine if the learning units improved students' decision making.

Project Deliverables: The two learning units, WEATHER and CLIMATE, are available on the project's website: *TeachingDecisionMaking.tamu.edu.* Each learning unit contains several modules and includes a list of required materials, background science information and teaching tips for teachers, as well as student worksheets and handout materials. A table of the national and Texas science standards covered in each learning module is included.

The availability of the learning units was announced in two journal articles in *Science Scope,* *"Weather to Make a Decision"* (February 2006) and *"Fires Floods and Hurricanes: Is Enso to Blame*" (March 2007). *Science Scope*, a peer reviewed publication of the National Science Teachers Association, is directed towards middle / junior high science teachers across the United States and Canada. It has a circulation of 18,000+ with a reading pass-along of 2.5 (http://tempo.nsta.org/advsciencescope).

A working paper that analyzes the educational outcomes and examines the significant factors affecting student performance is completed and will be submitted to an education science research journal in October 2007. A copy of this working paper follows this executive summary.

Mjelde, J.W., and K.K. Litzenberg. "Using Science Curriculum to Teach Decision Making: A Probabilistic Approach." Working Paper. Department of Agricultural Economics, Texas A&M University, College Station, TX. October 2007.

Using Science Curriculum to Teach Decision Making: A Probabilistic Approach

James W. Mjelde
Department of Agricultural Economics
Texas A&M University
College Station, TX
77843-2124

Kerry K. Litzenberg
Department of Agricultural Economics
Texas A&M University
College Station, TX
77843-2124

Working Paper. Department of Agricultural Economics, Texas A&M University, College Station, TX. 2007

Using Science Curriculum to Teach Decision Making: A Probabilistic Approach

Abstract

This study's investigated the comprehension and effectiveness of teaching formal, probabilistic decision-making skills to junior high school students. *DECIDE*, a learning unit that integrates mathematics, science, and decision-making concepts, is developed to provide the context as relevant previously developed curriculum did not exist at this grade level. The learning unit is best described as a partial or hybrid inquiry approach that follows national standards for science curriculum. Differences in students' pre- and post-test performance on a general decision-making test are statistically significant, indicating students can learn formal decision making skills in junior high. Given the statistically insignificance of race and gender variables, *DECIDE* is race and gender neutral. Exposing junior high school students to probabilistic information with decision-making skills may provide students with academic and life-long skills.

Keywords: climate / weather, decision-making, probability, integration

Using Science Curriculum to Teach Decision Making: A Probabilistic Approach

Everyday people are faced with demanding important cognitive tasks at work and at play (Jonassen, 2000); as such decision-making has been the focus of many studies from numerous disciplines. Consequences of poor or ineffective decisions are increasingly becoming more costly. Exposing students to decision-making skills using integrated mathematics, science, and probabilistic information may provide students with educational and life-long skills. The majority of studies directed toward students have focused on how students make decisions (Hogan, 2002; Baumberger-Henry, 2005; Bell *et al*., 2005; Aikenhead, 1989) and not teaching students how to make decisions. Along this line, Baumberger-Henry (2005, p. 244) notes "… the change scores might have been significant if actual problem-solving steps had been taught to the experimental group." Other authors have also stressed the need to teach problem-solving skills to students (Andrews and Reece-Jones, 1996; Dowd and Davidhizar, 1999).

Zohar and Nemet (2002) examined the outcome of a teaching unit that explicitly integrates the teaching of general reasoning patterns using science content. They conclude "Students were able to transfer the reasoning abilities taught in the context of genetics to the context of dilemmas taken from everyday life" (Zohar and Nemet, 2002, p. 35). Ratcliffe (1997) developed a decision-making structure based on both normative and descriptive models. However, mathematical aspects of implementing normative models and provisions for implementing the decision are not included. Some key features associated with well reasoned decisions identified by Ratcliffe (1997) include understanding procedures for rational analysis of the problem, use of available information, and how scientific evidence may assist in the decision.

The study reported here addresses two of the issues raised in the previously mentioned studies. The primary objective is to teach formal, probabilistic decision-making skills to junior high school students to improve their life-long decision-making skills. To address this objective, two specific research questions are proposed. First, can students at the junior high school grade level comprehend the formal probabilistic decision-making approach including the need for science data, information, and mathematical requirements? Second, can exposure to formal modeling approaches improve junior high school students' decision making abilities? To our knowledge, no curriculum exists at the junior high level that provides instruction in formal probabilistic decision-making models. Watson (2006) and Burrill and Romberg (1998) discuss that students begin to understand the use of data in depth at the targeted grade level. However, neither takes statistical concepts to the formal probabilistic decision-making level. Therefore, the first step to address these questions was to develop a curriculum to teach decision modeling.

DECIDE, an integrated multi week approach to teaching weather and climate (weather occurring over a period of two weeks or longer) forecasts and potential applications to decision making, was developed to provide the context. *DECIDE* can best be described as a partial or hybrid inquiry approach (Trumbull *et al*., 2005). Over the approximate two week learning period, instruction is accomplished through inquiry based problems, direct teacher instruction, cooperative activities based on the jigsaw method, and group laboratory experiments. Decision theory concepts provide the integrating mechanism in *DECIDE*. The research questions are addressed by administering pre- and post-tests to junior high students in classroom settings. Between the pre- and post-tests, *DECIDE* is taught to formally introduce the students to probabilistic decision modeling.

This study does not address the equally important issues of pedagogical approach and context. The integrated hybrid inquiry approach is not compared to or contrasted against other approaches. The pedagogical approach was based on previous studies noting the value of these approaches (see Czerniak, 2007 and Anderson, 2007 for recent overviews). Another reason is provided by Hogan (2002, p. 364), who argues "… that a most crucial way in which science education should be extended to prepare students for making environmental management decisions is to develop their systems thinking abilities. …" Systems thinkers examine an integrated picture of the issue at hand. Similarly, the context of climate and weather is not the subject of the study. Climate and weather are part of the junior high science curriculum; as such they provide a context that easily fits into the curriculum as defined by national and state standards. Although students' lives are impacted every day by weather, they do not readily recognize the importance of understanding weather principles (and scientific principles, in general, for that matter) in their everyday life.

Brief Decision Making Theory

A useful definition of decision making is the process of choosing between two or more alternatives with potentially different outcomes. Research on decision making can be found in a diverse realm of disciplines including education, economics, medicine, political science, engineering, and psychology to name just a few (Slovic, Fischhoff, and Lichtenstein, 1977). Research into decision making at the K-12 level tends to follow two perspectives, behavior or descriptive and normative (Furby and Beyth-Maron, 1992). Descriptive decision theory perspective examines how students make decisions. This important line of research "… focuses on how people identify alternative options, how they identify possible consequences, how they assess the desirability and likelihood of those consequences occurring, and what decision rules they use to reach a choice" (Furby and Beyth-Marom, 1992 p. 4). Normative models of decision theory are concerned with prescribing courses of action that conform most closely to the decision maker's beliefs and values (Slovic, Fischhoff, and Lichtenstein, 1977) . Both perspectives have similar structure or steps in analyzing what people do or describing what people should do (Ratcliffe, 1997; Furby and Beyth-Marom, 1992). As with any classification, these steps vary by situation and study, but generally the decision making steps are 1) problem identification, 2) gather relevant information including identifying decision alternatives, possible outcomes, and random events, 3) model formulation and analysis, 4) choosing the appropriate decision, and 5) decision implementation, review, and evaluation.

Reviews of the relevant literature in various disciplines associated with decision making can be found in Shulman and Elstein (1975), Beyth-Marom et al. (1991); Hulton 2001). By far, the majority of the studies at the K-8 level have been focused toward the behavioral perspective. The current study is focused on a normative perspective, focusing on formulation of a formal probabilistic model, model analysis, and lab exercises that illustrate how random events can impact the outcomes even if the decision implemented was the "best" decision. Because the current study is directed more towards the normative perspective, only selected literature of this path is discussed. To the authors' knowledge, no previous study has concentrated on the aspects that are the focus of this study.

Ross (1981) addresses information processing skills in grades 7 and 8. Results suggest his instructional program, in his words "…worked, at least in part" (Ross, 1981 p. 293). Mann et al. (1988) also conclude their course in decision making improves students' knowledge, confidence in decision making, and self-reported decision habits. They used several testing measures including a 30 question (24 multiple choice and 6 open ended questions) intended to measure different aspects of decision making. Statistical significant differences where found on decision strategy questions. Multiple choice questions were scored as either correct or incorrect.

In their introduction to their book, Baron and Brown (1991) note that most of the approaches taken by authors of the various chapters at least implicitly teach normative models of decision making. No study, however, uses the formal probabilistic model used in the current study at the junior high level. Martin and Brown (1991) state their experience in teaching decision making is that most people exhibit discomfort with numerical calculations. As such, they suggest the used of analog devices such as using a balance beam to enhance student decision making without explicit expected value calculations. Swets (1991) presents coursework based on dice and expected values directed towards high school students. No evidence is presented of the ability of students to comprehend the material.

Ratcliffe (1997) developed a structured decision making steps for use in science class of 15-year old boys for determining decision tasks. Steps of the decision making process explicitly not included are mathematical aspects and provisions for implementing the decisions. Fifteen of the students were interviewed two months after undertaking the decision tasks, "None recollected the detail of the decision-making elements" (Ratcliffe, 1997, p. 178). Eight of the 15 boys did indicate exposure to the material had aided their decision-making. She concludes, along the lines of Beyth-Marom et al (1991) that we should be skeptical of claims of improved decision-making based on short time periods and normative teaching aids. Retention of learning, a basic concern in education (Bacon and Stewart, 2006), will impact the long-term usefulness of curriculum in decision making.

Methodology

As noted earlier, to our knowledge no curriculum material exists that teaches junior high school students formal probabilistic decision-making approach the first step is the development of *DECIDE*. In the Spring of 2005, *DECIDE* was beta tested in six, sixth grade classroom in

College Station, TX with the researchers in daily contact with the teacher. All classes were taught by the same teacher.

After revision, the next step is to address the two specific research questions: 1) can students understand the probabilistic decision making model; and 2) does exposure to the model improve their decision-making skills. A classroom experiment involving several teachers, numerous classrooms, differing amount of material presented, and pre- and post-tests of decision-making abilities was designed. Each of these components is discussed.

Experimental Design

Several factors were taken into account in designing the classroom experiment. First, willing junior high school teachers had to be found. A small financial incentive was paid to participating teachers. Second and foremost, the school environment in Texas is being driven by the statewide assessment program, Texas Assessment of Knowledge and Skills (TAKS). As mandated by the 76th Texas Legislature in 1999, TAKS was first administered during in the 2002-2003 school year. Satisfactory performance on the TAKS has become a requirement for grade advancement and graduation in Texas (Texas Education Agency, 2006). As such, showing how *DECIDE* meets TEKS objectives was paramount to finding teachers willing to participate. Further, in this environment the teachers had to be secure in their job to try something new. Teachers also had to be willing to devote approximately two weeks of classroom time to the project. Three teachers, one from College Station, TX and two in Victoria, TX agreed to teach *DECIDE* during Spring 2006. Two taught sixth grade, while the third taught eighth grade. All three teachers are female and have multiple years of teaching experience. Principals at both schools supported the teachers' involvement in this project. The teachers were responsible for teaching the units, administrating the pre- and post-tests, and providing the researchers with the completed answer sheets.

Using three teachers provided the following experimental design. First, control classes are designated. In these classes, the teacher introduced decision making and discussed how science can help in the decision making process. Science principles were taught, but no decision making tools were taught. Four eighth grade classes in Victoria, TX served as the control group. Next, one teacher agreed to rigorously teach all of the *DECIDE – Weather Unit* to her five sixth grade classes in Victoria. These classes are designated the complete group. Third, for a variety of reasons including standardized testing and the reality that teachers will likely adopt parts but not all of the material contained in *DECIDE*. A partial group is included in the experimental design. The third teacher agreed to teach science principles and decision making, but was selective on the material covered. Six, sixth grade classes in College Station are in this partial group.

To increase realism, the researchers were provided only minimal support during the testing of *DECIDE*. Support consisted of meeting with the teachers before teaching the material to briefly review the material. Minimal support is the most realistic classroom scenario. If *DECIDE* is to be used in other classrooms, the developers would not be able to provide more than minimal support. Further, minimal support minimizes any potential bias in students' behavior caused by having the researchers in the classroom, a potential Hawthorne effect (Mayo, 1946).

Both pre- and post-tests were administered to each group: beta test; control; partial; and complete. One class period was devoted to each of the tests. After administering the pre-test, each group was given an approximately two-week learning unit. After completion of the learning unit, the same test was administered as a post-test.

Pre- and Post-Tests

The pre- and the post-tests are designed to measure the students' abilities to assimilate the necessary components to make probabilistic decisions. Not only was the decision important, but the information necessary to make probabilistic decisions is also important. The test consists of seven different situations. Associated with each situation is a series of questions, which vary by situation. A total of 38 multiple choice questions each with five potential answers constitutes the test. Thirteen questions dealt with probabilities (denoted as probability). Thirteen questions also dealt explicitly with either making a decision or explaining the reason for choosing a decision (denoted as decision). Seven questions required the student to make an inference beyond the decision made or situation (denoted as inference). The above 33 questions were general in nature and not specific to the material taught. Finally, five questions dealt explicitly with the material taught, calculation of expected value and decision trees (denoted as specific). Probability and specific questions address the research question can students comprehend the formal probabilistic decision-making approach, whereas decision and inference questions are directed towards the research questions can exposure to formal modeling approaches improve students' decision making abilities? The pre- and post-test did not measure knowledge of the scientific concepts.

Two of the situations from the pre- and post-tests are given in Appendix A, along with five questions. Not all the situations contained questions from each of the above sets, probability, decision, inference, and specific. The two situations and five questions illustrate the type of questions in each set. Question 1 falls into the probability set; students are asked to provide the probability of wind speed. Making a decision and supporting their answer is the subject of questions 2 and 3. In question 4, students must make an inference about the decision making process. Finally, question 5 requires the student to calculate an expected value, a specific issue covered in *DECIDE* (see *DECIDE* section below). The full test is available free of charge on the *DECIDE* web site (http://TeachingDecisionMaking.tamu.edu).

Pre- and Post-Test Analysis

Ordinary least squares models are estimated to address the research questions. The general form of the models estimated is

$$\text{diff} = f(\text{pre-test, gender, race, teaching group}) \tag{1}$$

where diff is the difference between the student's pre-test and post-test scores, f indicates a function of, pre-test is the student's score on the pre-test, and gender, race and teaching group are qualitative variables discussed below. Pre-test scores are used as a proxy for the student's prior knowledge. As a student scores higher on the pre-test (higher prior knowledge), they have less chance for improvement on the post-test. A negative sign associated with the coefficient on the pre-test variable is expected. The use of pre-test scores is consistent with earlier studies such as Baumberger-Henry (2005). Gender is a qualitative variable, with zero indicating a female student and a one indicating a male student. Three qualitative variables are used to represent race: African American; Asian; and Hispanic. Gender and race variables are included to determine if there are any gender and race effects. Care was taken in developing *DECIDE* that it would be gender and race neutral; coefficients are, therefore, expected to be insignificant. Finally, three variables are used to represent the teaching content the students received: beta test; partial; and complete. The base group is the control group. Coefficients associated with the teaching variables are expected to be significant and positive. Complete is expected to have the largest coefficient. The relationship between partial and beta test is not hypothesized. Several conflicting reasons account for not hypothesizing a relationship. The partial teaching content group received less instruction material. As such, beta test would have a larger coefficient. However, the beta test group teaching material was less coherent. As noted previously, the material was revised after the beta test. This less coherent teaching content would indicate a smaller coefficient associated with the beta test group.

The research questions are addressed by examining the coefficients associated with the teaching variables. Positive and statistically significant coefficients indicate students in the test groups, either beta, partial or complete, answer more questions correct on the post-test than the control group. Each set of questions, probability, decision, inference, and specific is analyzed individually, along with analyzing all questions together.

DECIDE Learning Units Development

Because of the importance of *DECIDE* in providing the context, *DECIDE* is presented in some detail. *DECIDE,* which contains both Weather (Hoyle *et al.*, 2006) and Climate Units (Mjelde *et al.*, 2007), is a teacher-friendly, integrated approach designed to stimulate learning by allowing students to make decisions using the scientific principles. Students must develop models and use decision analysis tools to evaluate alternative decisions. All the materials necessary for the units are provided.

DECIDE designers began by holding focus groups with middle school science teachers to specifically determine how probabilistic decision making could be integrated into current teaching objectives. The development goal could best be described as developing material that augments the current curriculum. Teachers must achieve standard learning objectives; the use of the probabilistic models must add to the learning environment. A large part of the discussion concentrated on how the use of probabilistic information, in general, and climate / weather forecasts, in particular, can enhance the junior high curriculum. Next, several focus groups with sixth grade students were held. The discussion centered on activities they enjoyed and the related decisions they made. As activities were identified, the discussion was directed towards how weather may affect students' plans to participate in these activities. It was amazing how many different activities mentioned are impacted by weather. One interesting, unexpected example, of an activity affected by weather was skeet shooting. The students realized that they could not shoot skeet if it was raining. Therefore, a plan to go skeet shooting included an implicit weather forecast of no rain. The goal of the focus groups was to determine how to relate the units of instruction to decisions students make. At the same time, the units of instruction must be new to the students and not a rehash of previous material. The units of instruction, therefore, provide students with knowledge that they can use to construct credible inferences that go beyond direct experiences or literal comprehension.

Two important aspects in developing *DECIDE* were the recognition of different abilities between the three targeted grade levels and that many teachers already have well-developed science lessons. *DECIDE* is developed so different mathematical abilities are accommodated. Although *DECIDE* was designed to be a self contained learning unit, teachers can partially substitute their currently existing weather / climate science curriculum into the *DECIDE* learning modules.

The basic integrating decision tool in *DECIDE* is the decision tree, a formal probabilistic decision making tool. Students develop numerous decision trees within each unit; however, each unit is built around a particular problem. The Weather Unit's main problem is deciding whether to have an event inside or outside to raise money for the school; whereas, the Climate Unit problem is deciding to join either an indoor or an outdoor soccer league based on rainfall forecasts. These activities were chosen because of their unilateral interest, appeal, and familiarity displayed by the focus group of students.

To illustrate the concept of decision trees, consider the problem faced in the planning an event to raise funds for the school (Figure 1). The square represents the decision point; hold the event either outside or inside. After the decision is made, some random (with an associated probability) event, in this case rain, occurs and is represented by the dots. Arrows represent time. A set of outcomes (costs and benefits) dependent on the decision made, as well as the random event completes the decision tree. In this case, the outcomes are the number of foursquare courts that can be constructed with the funds raised from either an indoor or outdoor event and if it rains or does not rain. The most important aspect of decision trees is the model-building component, which explicitly forces the student to recognize decision alternatives, specifying random events that impact the decision process, probabilities associated with the events, science knowledge necessary to develop forecast, and potential outcomes.

Each unit begins with an inquiry based activity (Tables 1 and 2). In the case of weather, the activity is directed towards what is important in planning an indoor or outdoor activity; whereas the climate unit asks the question should the student join an indoor or outdoor soccer league. The discussion in this activity is directed towards weather (or climate) and how to make a decision. Using the inquiry-based activity to stimulate interest, *DECIDE* then covers the important elements in the decision tree. In creating decision trees, students learn about the necessity of setting goals, considering alternative decisions, random events, information and data gathering, and outcomes. Next, the science component is brought into play by asking students, “How do scientists develop weather (or climate) forecasts?” Both the Weather and Science Units use jigsaw based modules for learning science principles. These activities culminate in students using actual data to generate simple forecasts for use in decision trees. *DECIDE* uses

College Station, TX weather and climate data, but the teacher could substitute data from their local areas (weather data source is provided in the teacher materials). Mathematics and statistics is brought into play in that the “best” decision is the one that maximizes the expected value. In the case of figure 1, the decision that maximizes the expected value is to hold the FUNDFEST outside. Expected value, a statistical concept, is calculated by multiplying the probability of a random event occurring by the outcome and then summing these products for the particular decision. This is shown in the boxes in Figure 1. (A teacher’s manual is provided to the teachers to help introduce students to the expected value concept.) Finally, the concept of probabilities is reinforced through a decision making lab. Lab activities illustrate that in life ex ante (meaning before the random event) decision making does not always result in the optimal decision ex post (after the random event). Although the best decision is to hold the FUNDFEST outdoors, there is a chance it will rain, in which case the FUNDFEST should have be held indoor. Given that the decision must be made before the rainfall outcome is known, the decision to hold the FUNDFEST outdoors was ex ante (before the random event) optimal. Although *DECIDE* contains much more information, this example illustrates the nature of the probabilistic decision making model. In addition to the classroom material, *DECIDE* contains numerous activities and homework suggestions. *DECIDE* is available free of charge on the *DECIDE* web site (http://TeachingDecisionMaking.tamu.edu).

Results

To comply with regulations on research on human subjects, both students and their parents or guardians were informed of the nature of the research. Only those students whose parents indicated a willingness to be included in the study are included. In line with Zohar and Nemet (2002), students who did not complete both the pre- and post-tests are deleted from the analysis. Almost 400 students participated in the project (Table 3). The number of students is approximately evenly split between male and female students. White students dominate the racial mix in College Station. In Victoria, white and students of Hispanic background are approximately equal in numbers. The racial mix approximates the school and cities racial make up (Table 4).

Estimation Results

Ten models are estimated (Tables 5 and 6). One model uses all questions in the pre-and post-tests. Four other models use only those questions associated with the categories previously described: probability, decision, inference, and specific. In addition, the models are estimated including the students in the beta test (Table 5) and excluding the beta test students (Table 6).

Estimation results for the five models and two data sets are surprisingly similar. Adjusted coefficients of determination (adjusted R^2), which range from 0.38 to 0.58 among the 10 estimated models, indicates approximately 40-60% of the variance is explained by the models. Joint significance of all the coefficients is tested using an F-test. In all cases, the F-test rejects the null hypothesis that all coefficients are jointly equal to zero at an alpha level of 5%. Because of the different number of questions associated with the different models, care must be exercised in direct comparison of the models. The base in all models is a white, female student in the control teaching group. The coefficients are interpreted in relation to this base.

In all models, the coefficients associated with pre-test scores are negative and significant at an alpha level of 5%. As expected, students who scored higher on the pre-test had smaller differences between their pre- and post-test scores. Of the forty gender and race coefficients, only the coefficients associated with Hispanic in the inference models are significant (5% level using all observations and 10% level if the beta test students are omitted). In both cases, students of Hispanic origin score slightly higher than white students. The general overall insignificance of these coefficients indicates the *DECIDE* material is race and gender neutral.

In the models, the coefficients associated with partial and complete teaching content are positive and significant at an alpha level of 5%, except partial in the probability models. Partial is, however, significant at an alpha level of 10%. As expected, students receiving partial and complete teaching content improved their test scores relative to the control group. Coefficients associated with the beta test group are mixed in terms of significance and sign. Surprisingly, the coefficients associated with the beta test is negative in the probability model, however, it is highly insignificant. This coefficient is also insignificant in the specific model. Beta test group is significantly different than the control group in the decision model at the 5% level and significant at the 10% level in the all and analysis models.

Within a particular model, the partial teaching content coefficient is larger than the beta test coefficient. As noted earlier, no relationship was postulated for the relationship between these two teaching content variables. Results seem to indicate continuity in teaching the material is more important than omitting some of the material in *DECIDE*. As expected, the coefficients associated with the complete group are larger than with either of the other teaching content variables. However, the magnitude of the complete coefficients relative to the partial and beta test coefficients is unexpected. Between the two data sets, the magnitude and significance of the coefficients vary only slightly (Table 5 vs. Table 6). Inclusion or exclusion of the beta test group has only minor affect on the inference from the models.

Teacher Debriefing

In addition to the pre- and post-tests, brief meetings were conducted with each teacher after they completed the units. One of the initial steps in developing *DECIDE* was the focus group discussion with teachers and students concerning decision making and weather / climate issues. Therefore, it is not surprising that all teachers indicated the students liked the decision making examples in *DECIDE*. Further, students generally felt the examples were relevant to their lives. Most important, two teachers indicated a reluctance to teach material outside of their area of expertise. Partial inquiry and integration of subject matter is challenging and complex even in the best of situations. Teachers committed to teaching *DECIDE* will face this wall of inquiry and integration. Venville *et al.* (1998) indicate teachers are aware of the benefits of integrated curriculum, but they are concerned about student learning during integrated units of work because of limited knowledge content outside of their specialties. Czernaik (2007) in her overview also notes the lack of training in teaching integrated approaches is a pitfall in integrated curriculum.

As noted earlier, the difference in the magnitude of the coefficients between the partial and complete teaching content variables is unexpected. Differences in the material covered were not as different as the coefficients seem to indicate. In debriefing the teachers, two potential reasons arose. First, the teacher teaching the partial content unexpectedly had to represent her school at a district wide meeting. This discontinuity in teaching may have lowered post-test scores. Second, it become evident the teacher associated with the complete teaching content was an exceptional teacher. Trumbull *et al.* (2005) also indicated an exceptional teacher effect. In line with Trumbull *et al.* (2005), experimental design and budget constraints does not allow us to explore differences in the teachers in more depth.

The teachers indicated they planned to incorporate some of the *DECIDE* material into their curriculum, even after financial remuneration was over. All teachers indicated the material was too long given time given TAKS constraints to incorporate all of *DECIDE* into their curriculum. Teachers around the U.S. have inquired about its use since publication. Most have indicated if they incorporate *DECIDE* material into their classroom, it will be a partial incorporation.

Discussion

Significant differences between the control group and the partial and complete groups in the specific and probability regressions indicate that junior high school students can comprehend formal probabilistic decision models. Similarly, significant differences between the groups in the decision and inference regressions, indicates exposure to formal decision models improves the students decision making skills. Previous studies have indicated mathematical probabilistic content may be should not be part of decision making unit aimed at the junior high level because of discomfort toward numerical calculations (Martin and Brown, 1991) and/or inadequate knowledge base for these grade levels (Ratcliffe, 1997). Both teacher debriefing and inference from the statistical estimations indicate junior high students can understand mathematical decision-making models and such understanding may improve decision making ability.

The results of this pilot study clearly shows student improvement in decision making after the learning unit has been taught, especially in the complete group. Retention of the skills, however, is necessary for lifelong use. Research on the lifelong retention of decision-making skills is needed. In looking beyond this study, an interesting observation on decision-making ability and retention can be observed. First, a debate exists concerning if teaching decision making helps. Like the current study, previous studies have concluded students benefit immediately from teaching decision making skills. Several studies have questioned the retention of the skills (Mann et al, 1988: Beyth-Marom et al 1991; Ratcliffe, 1997). Similar to most skills, continued exposure, understanding, and extension of the skills is necessary. For example, students are taught mathematical skills starting in pre-K and continuing through college. For longer term improvement in decision-making skills, curriculum development that continuously teaches such skills is necessary. This observation is along the lines of Aikenhead (1984) that skills need to be continuously practiced and evaluated. Piecemeal approach appears to work short-term, but longer term requires additional investment in teaching decision-making skills. Results of this study indicate teaching decision-making skills that integrated science, mathematics, and other subjects could be a part of the curriculum at the junior high level. However, this opens up another debate that of curriculum reform in education, which is beyond the scope of this study.

This research has shown that an integrated learning unit for junior high school students can be developed that is gender and race neutral, and effective in educating students in mathematics and science while improving decision making skills. The statistically significant differences in pre- and post-test performance of the students in the study should encourage teachers to teach decision-making skills into their science classrooms. Inquiry and integrative teaching approaches have demonstrated benefits, but these benefits came at a cost of teaching outside their area of expertise. The authors look forward to junior high school teachers adopting *DECIDE* learning modules. The adaptability of *DECIDE* allows teachers to supplement current teaching curricula with area specific data. It would also be possible for teachers to change the decisions in *DECIDE* to other situations they deem more relevant for their students. However, the results showing the most improvement in performance comes from using the complete unit may encourage adoption of the entire *DECIDE* learning modules.

Acknowledgements

This research was partially supported by the Department of Commerce, National Oceanographic and Atmospheric Administration Grant NA 030AR4310055. Special thanks are given to teachers, Julie Hoyle, Sarah Funkhouser, and Sharon Holochwost, and administrators from the College Station and Victoria Independent School Districts in Texas without whose help this project could not have been completed.

References

Aikenhead, G.S. (1984). A review of research into the outcomes of STS Teaching. In K. Boersma, K. Kortlnad, J. Van Trommel (eds), Proceedings of the 7th OISTE Symposium (Enschede: National Institute for Curriculum Development), pp. 13-24.

Aikenhead, G.S. (1989). Decision-making theories as tools for interpreting student behavior during a scientific inquiry simulation. Journal of Research in Science Teaching, 26, 189-203.

Anderson, R.D. (2007). Inquiry as an organizing theme for science curricula. In Handbook of Research on Science Education S.K. Abell and N.G. Lederman, eds. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. pp. 807-830.

Andrews, M., & Reece-Jones. P. (1996). Problem-based learning in an undergraduate nursing programme: a case study. Journal of Advanced Nursing, 23, 357-365.

Bacon, D.R. & K.A. Stewart. (2006). How fast do students forget what they learn in consumer behavior? A longitudinal study. Journal of Marketing Education, 28, 3, 181-192.

Baron, J. and R.V. Brown, eds. (1991). Teaching Decision Making to Adolescents. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. 340 pages..

Baumberger-Henry, M. (2005). Cooperative learning and case study: does the combination improve students' perception of problem-solving and decision making skills. Nurse Education Today, 25, 238-246.

Bell, M.L., Kelly-Baker, T., Rider, R., & Ringwalt. C. (2005). Protecting you / protecting me: effects of an alcohol prevention and vehicle safety program on elementary students. Journal of School Health, 75, 171-177.

Beyth-Maronm, R., B. Fischhoff, M.J. Quadrel, & L.Furby. (1991). Teaching decision making to adolescents: a critical review. In Teaching Decision Making to Adolescents, J. Baron and R.V. Brown, eds., Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. pp. 19-59.

Burril, G. & T.A. Romberg. (1998). Statistics and probability for the middle grades: examples from mathematics in context. In S.P. Lajoie (ed), Reflections on Statistics Learning, Teaching, and Assessment in Grades K-12. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. 336.

College Station Independent School District, http://www.csisd.org/ Accessed December 2006.

Czerniak, C.M. (2007). Interdisciplinary science teaching. In Handbook of Research on Science Education S.K. Abell and N.G. Lederman, eds. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. pp. 537-559.

DECIDE - Teaching Decision Making Using Weather and Climate Principles. http://teachingdecisionmaking.tamu.edu/ 2006.

Dowd, S., & Davidhizar. R. (1999). Using case studies to teach clinical problem-solving. Nurse Educator, 25, 42-46.

Furby, L. and R. Beyth-Marom. (1992). Risk taking in adolescence: a decision-making perspective. Developmental Review 12, 1-44.

Hogan, K. (2002). Small groups' ecological reasoning while making an environmental management decision. Journal of Research in Science Teaching, 39, 341-368.

Holye, J.E., Mjelde, J.W., & Litzenberg, K.K. (2006). Weather to make a decision. Science Scope, 29, 24-27.

Hulton, L.J. (2001). Adolescent sexual decision-making: An integrative review. The Online Journal of Knowledge Synthesis for Nursing. 8, Document No. 4. October 3, 2001. http://www.stti.org/articles/080004.htm

Jonassen, D.H. (2000). Toward a design theory of problem solving. Educational Technology Research and Development, 48, 63-85.

Mann, L., R. Harmoni, C. Power. G. Beswick, and C. Ormond. (1988). Effectiveness of the GOFER course in decision making for high school students. Journal of Behavioral Decision Making 1, 159-168.

Martin, A.W., & R.V. Brown. (1991). Analog devices for teaching decision skills to adolescents. In Teaching Decision Making to Adolescents, J. Baron and R.V. Brown, eds. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. pp. 207-235.

Mayo, E. (1946). The human problems of an industrial civilization (2nd ed). Boston, Division of Research, Graduate School of Business Administration. Harvard University, Cambridge, MA.

Mjelde, J.W., Litzenberg, K.K, Holye, J.E., Holochwost, S.R., & Funkhouser. S. (2007). Fires, floods, and hurricanes: is ENSO to blame? Science Scope, 30, 38-42.

Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. International Journal Science Education, 19, No. 2, 167-182.

Ross, J.A. (1981). Improving adolescent decision-making skills. Curriculum Inquiry 11: 279-295.

Shulman, L.S. & A.S. Elstein. (1975). Studies of problem solving, judgment, and decision making: Implications for education research. Review of Research in Education 3,3-42.

Slovic, P., B. Fischhoff, and S. Lichtenstein. (1977). Behavioral decision theory. Annual Review Psychology 28:1-39.

Swets, J.A. (1991). Normative decision making. In Teaching Decision Making to Adolescents, J. Baron and R.V. Brown, eds. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. pp. 273-296.

Texas Education Agency. http://www.tea.state.tx.us/student.assessment/ Accessed September 2006.

Trumbull, D.J., Bonney, R., & Grudens-Schuck, N. (2005). Developing materials to promote inquiry: lessons learned. Science Education, 89, 879-900.

U.S. Census Bureau. http://factfinder.census.gov/servlet/GCTTable?_bm=y&-geo_id=04000US48&-ds_name=DEC_2000_SF1_U&-_lang=en&-redoLog=false&-mt_name=DEC_2000_SF1_U_GCTP6_ST7&-format=ST-7&-CONTEXT=gct Accessed December 2006.

Venville, G., Wallace, J., Rennie, L., & Malone. J. (1998). The integration of science, mathematics, and technology in a discipline-based culture. School Science and Mathematics, 98, 294-302.

Watson, J. M. (2006). Statistical Literacy at School. Lawrence Erlbaum Associates, Publishers, Mahwah, NJ. 306 pages.

Zohar, A., & Nemet, F. (2002). Fostering students’ knowledge and argumentation skills through dilemmas in human genetics. Journal of Research in Science Teaching, 39, 35-62.

Table 1. Learning Modules at a Glance – Weather Unit

Learning Module	Student Learning Objectives	Learning Activities
Learning Module 1 *Developing a Decision-Making Model* – 1 Day	The student: 1. Identifies weather as an important factor in planning an outside activity. 2. Develops a simple probabilistic decision-making model. 3. Works cooperatively in groups.	Journal / Bell Work Introduction of Simple Decision-Making Problem Development and Completion of Decision-Making Decision Tree Models Discussion of Weather Forecasts Assessment / Homework
Learning Module 2 *Probable Cause* – 1 Day	The student: 1. Works cooperatively in groups. 2. Understands the concept of probability. 3. Completes a data table and constructs a graph using the data. 4. Relates the probability experiment to the weather forecast. 5. Communicates valid conclusions. 6. Identifies how percentages are used in a weather forecast.	Journal / Bell Work Review / Introduce Probabilities Probable Cause Experiment *Collect Data* *Graph Data* *Calculate Probabilities* Class Discussion - Group Reports to Class Assessment / Homework
Learning Module 3 *Decision-Making Using Rainfall Forecasts – Foursquare Courts* – 2 Days	The student: 1. Advances their knowledge using decision trees. 2. Learns to calculate expected values. 3. Learns how to use expected values to evaluate decision trees and make a decision. 4. Develops an understanding that probabilistic forecasts, such as weather forecasts are not perfect. 5. Develops knowledge of the use of forecasts. 6. Works cooperatively in a group.	Journal / Bell Work Decision Model Development and Use *Continue Decision Tree Models* *Calculation of Expected Value* *Expected Value and Decision Making* *Student Activity – Decision Making* Individual Decision Making Probabilistic Nature of Decision Making Prelude to Next Learning Module Assessment / Homework
Learning Module 4 *Weatherman's Backpack -- Key Science Knowledge* – 4 Days	The student: 1. Works cooperatively in groups. 2. Demonstrates safe practices during field and lab investigations. 3. Implements investigation of hot/cold air fronts using water model. 4. Makes observations on the action of the hot/cold fronts. 5. Communicates conclusions. 6. Represents the natural world using models. 7. Collects, analyzes, and records information using tools. 8. Identifies the role of atmospheric movement in weather change. 9. Understands and is able to read a weather map. 10. Identifies and defines the symbols present on a weather map. 11. Recognizes local weather patterns. 12. Lists other factors that affect the forecast for rain.	Journal / Bell Work Jigsaw Approach to Weatherman's Backpack Suggested Experiments *Probability Activity - Understanding the Difficulty in Forecasting the Future* *Hot / Cold Water Experiment* *Temperature Around Town - Impact of Concrete and Asphalt* Weather Map Drawing and Inference Assessment / Homework
Learning Module 5 *Probabilistic Decision-Making and Weather Assessment* – 2 Days	The student: 1. Learns to create simple forecasts. 2. Demonstrates knowledge of both decision theory and weather principles. Assessment Module / Additional Learning Module	Science Concepts *Matching* *Multiple Choice* *Weather Map* Probabilities and Decision Making *One-day Ahead Forecasts* *Long-Range Forecasts* *Probabilistic Decision Making*

Table 2. Learning Modules at a Glance – Climate Unit

Learning Module	Student Learning Objectives	Learning Activities
Learning Module 1 *Joe Soccer's Problem* - - introduces decision-making and probabilistic thinking ~1-2 days	The student: 1. Identifies climate as an important factor in planning season-long activities. 2. Learns about decision problems. 3. Identifies informational needs.	Journal / Bell Work Decision Making Questions Group Discussions Class Discussion – teacher directed Closure – teacher directed Assessment / Homework
Learning Module 2 *El Niño / Southern Oscillation* -- introduces the El Niño / Southern Oscillation (ENSO) phenomena~ 1 day	The student: 1. Learns the difference between weather and climate. 2. Learns the basics of climate variability science principles. 3. Learns phenomena besides ENSO affects worldwide climate variability. 4. Learns scientists do not understand a lot of science that affects climate variability. 5. Gains an appreciation for the historical concept of science and climate variability.	Journal/Bell Work Review Day 1 - questions and answers Class Discussion - weather vs. climate Introduction to ENSO - teacher directed Assessment / Homework
Learning Module 3 *ENSO Jigsaw* -- key science knowledge module ~ 2 days	The student 1. Learns scientific aspects of ENSO. 2. Learns how ENSO affects climate variability in the U.S. and worldwide. 3. Works cooperatively in groups.	Journal / Bell Work ENSO Jigsaw or Becoming an Expert - only ENSO Jigsaw – only Teacher's own material Homework / Assessment
Learning Module 4 *Joe Soccer's Decision* -- returns to the Joe Soccer story and develops simple seasonal climate forecasts to be used in decision making ~ 1 day	The student: 1. Learns to use ENSO concepts to develop simple seasonal precipitation. 2. Learns to create and interpret simple graphs. 3. Develops an understanding that probabilistic forecasts, such as climate forecasts are not perfect. 4. Develops knowledge of the use of forecasts to make decisions. 5. Develops an understanding for probabilities and their use. 6. Works cooperatively in a group.	Journal / Bell Work – Review Joe Soccer Story Review / Introduce Probabilities - Optional ENSO Lab Decision - Making Lab Assessment / Homework

Continued

Table 2. Cont.

Learning Module	Student Learning Objectives	Learning Activities
Learning Module 5 *Formalized Decision-Making Using Climate Forecasts* -- integrates material from the previous learning modules into a unified decision making model ~ 1-2 days	The student: 1. Advances their knowledge by learning about and using decision trees. 2. Learns to calculate expected values. 3. Learns how to use expected values to evaluate decision trees and make a decision. 4. Develops knowledge of the use of climate forecasts. 5. Works cooperatively in a group.	Journal / Bell Work – Joe Soccer's Dilemma Decision Trees – direct instruction required Expected Values and Decision Making – direct instruction required Student Activity – Decision Making Activity Assessment / Homework
Learning Module 6 *Decisions and Outcomes – Probabilistic Nature – Optional Module* - - students explore probabilities associated with climate ~ *1 day*	The student: 1. Works cooperatively in groups. 2. Understands the concept of probability. 3. Completes a data table and constructs a graph using the data. 4. Relates the probability experiment to the climate forecasts. 5. Communicates valid conclusions. 6. Identifies how percentages are used in climate forecast.	Journal/Bell Work Review / Introduce Probabilities - Optional Decisions and Outcomes Lab Assessment / Homework
Learning Module 7 *Probabilistic Decision-Making and Climate Assessment ~ 1 day*	Assessment Module	Science Concepts *Matching* *Multiple Choice* *Weather Map* Probabilities and Decision Making *Probabilistic Decision Making*

Table 3.
Race and gender of students by study group

	Race				Gender		
	White	Hispanic	Black	Asian	Male	Female	Total
Beta Test	92	10	12	9	67	56	123
Control	27	24	3	2	26	30	56
Partial	86	18	9	5	57	61	118
Complete	52	40	7	1	46	54	100
Total	165	82	19	8	129	145	274
Grand Total	257	92	31	17	196	201	397

Table 4.
Comparison of student ethnicity between the sample and U.S. Census Bureau 2000, percentages

School	White	Hispanic	Black	Asian	Total
College Station					
College Station- Census[1]	75.7	10.0	5.4	7.3	98.4
CSISD[2]	72	15	8	4	99
College Station – All[3]	73.9	11.6	8.7	5.8	100
College Station – Beta Omitted[3]	72.9	15.3	7.6	4.2	100
Victoria					
Victoria – Census[1]	47.7	42.9	7.6	1.0	99.2
Victoria- Sample[3]	50.4	41.0	6.4	1.9	100

1) Data from the U.S. Census Bureau data. The federal government considers race and Hispanic origin to be two separate and distinct concepts. However, in collecting the sample data, Hispanic origin was considered a race.
2) Data from College Station Independent School District, http://www.csisd.org/
3) Sample data either using all the data for a particular school or omitting the beta test classes.

Table 5.
Ordinary least squares estimated coefficients for the five models using all observations

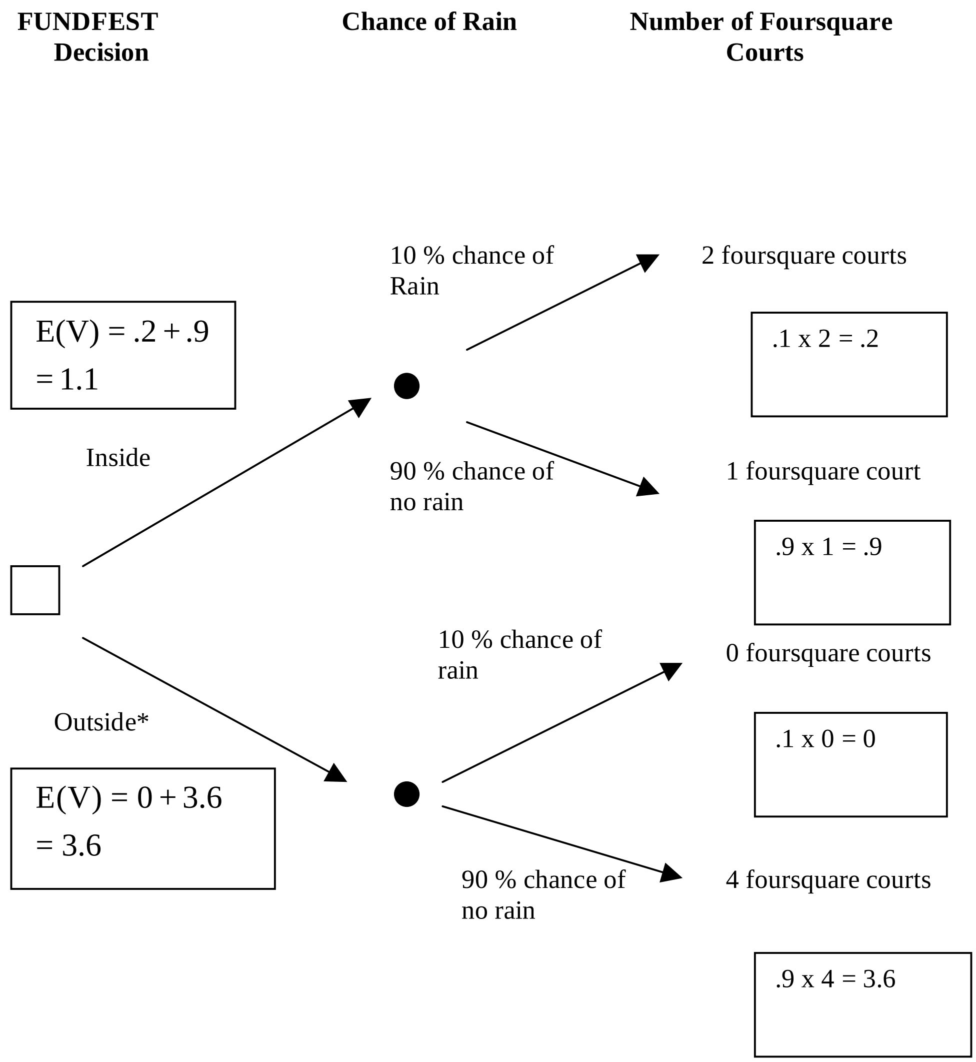
	Model				
Variables	All	Probability	Decision	Inference	Specific
Pre-test Score	-0.308*	-0.464*	-0.502*	-0.355*	-0.645*
	0.039	0.038	0.044	0.042	0.056
Race					
African American	0.051	-0.012	-0.526	-0.129	-0.036
	0.773	0.355	0.327	0.336	0.155
Asian	1.058	0.481	0.223	0.240	0.028
	0.995	0.459	0.425	0.439	0.207
Hispanic	0.375	-0.297	-0.025	0.466	0.050
	0.516	0.237	0.219	0.227*	0.106
Teaching Content					
Beta Test	1.196**	-0.060	0.733*	0.567**	0.140
	0.662	0.306	0.283	0.294	0.139
Partial	1.811*	0.513**	0.876*	0.738*	0.338*
	0.657	0.305	0.281	0.289	0.136
Complete	9.587*	2.199*	3.914*	3.581*	1.460*
	0.660	0.305	0.281	0.291	0.137
Gender Male	-0.200	-0.182	-0.046	-0.062	0.032
	0.401	0.185	0.170	0.178	0.083
Constant	7.330*	5.007*	3.529*	2.414*	0.944*
	1.126	0.467	.421	0.430	0.165
Adj. R^2	0.52	.38	0.53	0.45*	0.44
F-test	53.73*	31.48*	57.86*	41.38	40.64*
Observations	397	397	397	397	397
Number of Questions	38	13	13	7	5

Standard errors are given below the estimated coefficients.
* Significant at alpha = 5%
** Significant at alpha = 10%

Table 6.
Ordinary least squares estimated coefficients for the five models omitting the beta test observations

	Model				
Variables	All	Probability	Decision	Inference	Specific
Pre-test Score	-0.320 *	-0.505*	-0.475*	-0.433*	-0.704*
	0.047	0.0438	0.055	0.053	0.067
Race					
African American	1.122	0.248	-0.011	0.256	-0.007
	0.965	0.444	0.422	0.423	0.193
Asian	-0.1241	0.152	-0.331	-0.068	-0.168
	1.415	0.655	0.623	0.629	0.290
Hispanic	0.508	-0.259	-0.017	0.467**	0.024
	0.558	0.256	0.243	0.247	0.112
Teaching Content					
Partial	1.863*	0.565**	0.857*	0.728*	0.324*
	0.652	0.303	0.287	0.288	0.134
Complete	9.540*	2.193*	3.893*	3.548*	1.441*
	0.652	0.302	0.287	0.289	0.134
Gender Male	-0.807**	-0.322	-0.285	-0.257	-0.073
	0.474	0.219	0.208	0.211	0.096
Constant	7.813*	5.427*	3.437*	3.061*	1.113*
	1.299	0.518	0.494	0.507	0.179
Adj. R^2	0.58	0.44	0.56	0.52	0.51
F-test	54.78*	31.71*	51.61*	43.77*	42.25*
Observations	274	274	274	274	274
Number of Questions	38	13	13	7	5

Standard errors are given below the estimated coefficients.
* Significant at alpha = 5%
** Significant at alpha = 10%



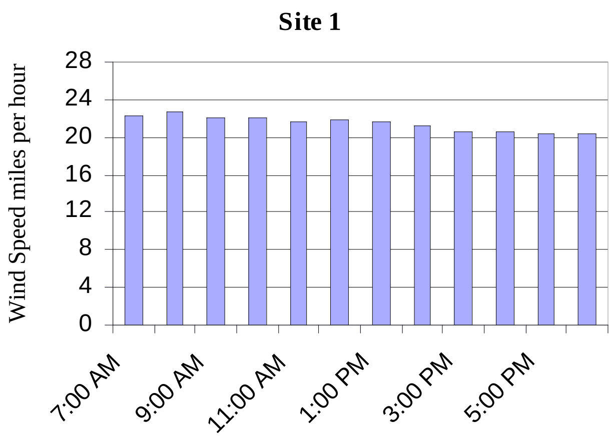
Key: E (V) – expected value

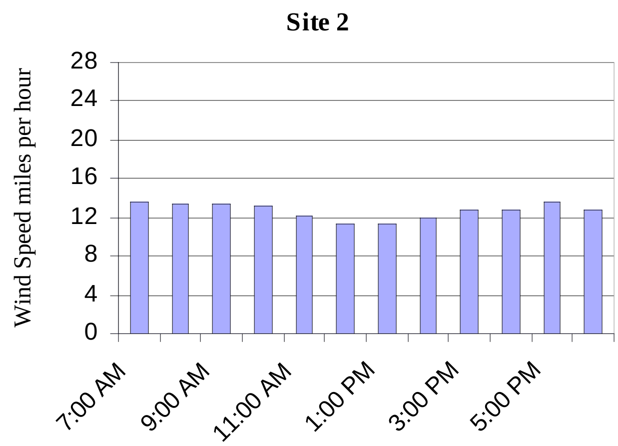
FUNDFEST Goal: Build the highest expected number of foursquare courts

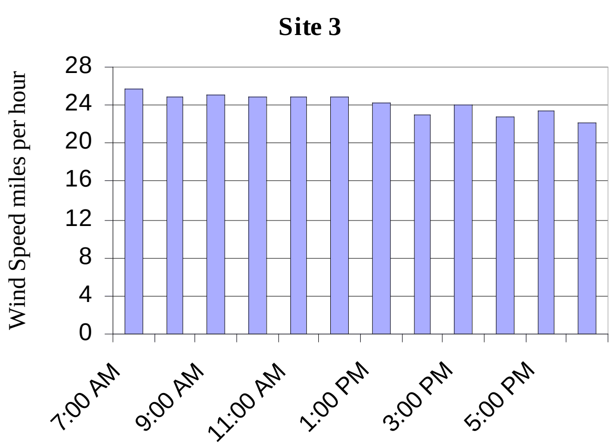
Figure 1. Decision tree of the decision of whether to hold the fund raising activity, FUNDFEST, indoors or outdoors.

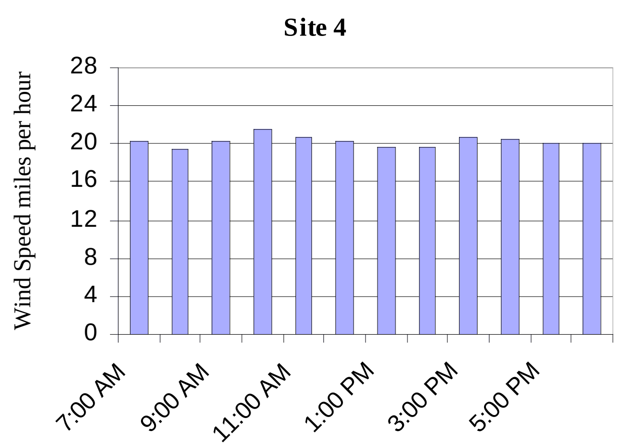
Appendix A
Situation 1

Angela is deciding where to put a new wind powered electricity-generating plant. Average wind speeds from 7 am to 7 pm are given in the graphs below for the four sites Angela is considering. The faster the turbines spin the more electricity is generated. If average wind speed is less than 12 miles per hour, the facility will not be able to generate electricity, as the turbines will spin too slowly. If wind speeds exceed 24 miles per hour, the facility must shut down because the turbines will be spinning too fast









1) What is the probability (percentage chance) that Site 1 will be generating electricity during the daylight hours?

a) 12 out of 12 hours
b) 10 out of 12 hours
c) 5 out of 12 hours
d) 8 out of 12 hours
e) I do not know what probability means.

2) If Angela's goal is to generate as much electricity as possible from the new wind power generating facility, which site should Angela pick for the new wind generating plant?

a) Site 1
b) Site 2
c) Site 3
d) Site 4
e) Either Site 1 or 4

3) Why should Angela pick from the Site you suggest in question 28?

a) The Site has a higher probability of average wind speed between 12 and 24
b) The Site has more hours with average wind speed greater than 12
c) The Site has more hours with a higher average wind speed
d) The Site has more hours with average wind speed greater than 24
e) Both a and c

Situation 2

Two roads, Road A and Road B, lead from your house to school. To get to school, you must cross railroad tracks which are two miles from your house. Road A has an underpass under the railroad tracks. Road B has just a crossing to drive over the tracks. It takes 12 minutes to get to school if you take Road A. If you take Road B, it takes 10 minutes if you do not get stopped by a train. If you get stopped by a train, it takes 15 minutes to get to school. The following are components of this decision making process.

1) Determine the probability of meeting a train
2) Determining which road to take
3) Get ready for school
4) Stopping for a train if required
5) Walking into the school

4) Which of the following is the proper order of the components?

a) 1, 2, 3, 4, 5
b) 1, 2, 4, 5, 3
c) 5, 2, 3, 1, 4
d) 3, 1, 2, 4, 5
e) 3, 2, 5, 4, 1

5) If you take Road A, what is the expected time it takes to get to school?

a) 10 minutes
b) 12 minutes
c) 15 minutes
d) 2 minutes
e) 5 minutes